

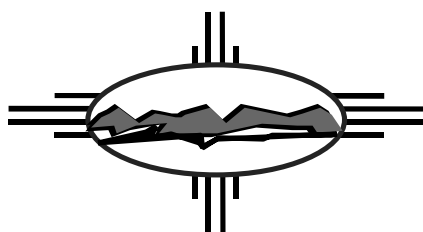
## STANDARD OPERATING PROCEDURE

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# ER PROJECT

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# General Borehole Logging

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# General Borehole Logging

**NOTE:** Environmental Restoration (ER) Project personnel may produce paper copies of this procedure printed from the controlled document electronic file. However, it is their responsibility to ensure that they are trained on and utilizing the current version of this procedure. The procedure author may be contacted if text is unclear.

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) states the responsibilities and describes the general process for obtaining borehole logging data of acceptable quality regardless of logging system or logging contractor, to meet the site-characterization and/or subsurface-sampling requirements for an operable unit (OU) at the ER Project and as part of a RCRA (Resource Conservation and Recovery Act) Facility Investigation (RFI).

## 2.0 TRAINING

- 2.1 All users of this SOP are trained by self-study, and the training is documented in accordance with QP-2.2.
- 2.2 The **Field Team Leader** (FTL) will monitor the proper implementation of this procedure and ensure that relevant team members have completed all applicable training assignments in accordance with QP-2.2.
- 2.3 The FTL responsible for borehole logging at a given OU should be familiar with
  - identified SOPs (see Section 7.0, References),
  - borehole logging technical specifications (BLTSs), and
  - contractor-specific logging procedures (CSLPs).

## 3.0 DEFINITIONS

- 3.1 Blueline — A general term for a hard copy of borehole logging data in the form of graphs of one or more logging parameters as a function of depth. Historically these have been blue-on-white prints on z-fold paper; although that format is becoming less common, the term blueline is still commonly used to denote hard copies of logs regardless of copy color.
- 3.2 Borehole corrections — Factors obtained from charts or algorithms to correct the logging data for any conditions that deviate from the conditions under which the system was calibrated; also known as environmental corrections.

For example, if the system was calibrated in a 6-in. borehole and is being used in a 4-in. borehole, the results may require correction. Other such corrections include fluid invasion, mudcake, casing, and borehole fluid.

- 3.3 Borehole logging — The process of making remote measurements of physical, chemical, or other parameters at multiple depths in a borehole.
- 3.4 Borehole Logging Technical Specifications (BLTSs) — Documents included in the site-specific Drilling Package that define the capabilities and data quality required of prospective logging contractors for a given OU or portion of an OU.
- 3.5 Calibration — A test or tests performed against known standards with a given logging system to verify that the system is functioning properly and to provide calibration values that allow the data from the system to be used quantitatively. Standard calibrations include shop calibrations which are performed at specified time intervals and after any equipment modification or repair, and field calibrations, which are performed immediately before and after a logging run or operation (also known as pre- or postlog calibrations).
- 3.6 Contractor-Specific Logging Procedures (CSLPs) — Documents supplied by the logging contractor and approved by the Operable Unit Project Leader (OUP), and the Principal Investigator (PI) for borehole geophysics before the contract is awarded. The CSLPs define the detailed procedures by which a given logging system will be calibrated and operated to achieve objectives for data type and quality given in the BLTSs.
- 3.7 Drilling fluid — A liquid or gas circulated into the borehole during the drilling process to cool and lubricate the bit and carry cuttings out of the borehole.
- 3.8 Drilling Package — A document package that includes a detailed Drilling Plan, Curation Plan, Sampling and Analysis Plan (SAP), and Geophysical Logging Plan, as necessary, to meet the sampling requirements defined in the site-specific SAP for a given OU. This package is prepared by the FTL or FTL's representative and is approved by the Subsurface Technical Team.
- 3.9 Fluid invasion — The migration of drilling fluid or one or more components of the drilling fluid into the pores, fractures, and other openings of the formation near the borehole.
- 3.10 Instrument drift — A systematic change in the output of a given logging system due to causes inherent in the logging system, such as changing tool temperature or the deterioration of an electronic component.
- 3.11 Log header — One or more pages of information included with each blueline and with logging data recorded digitally on magnetic tapes or disks. The minimum information required in the log header is specified in the BLTSs

and includes such information as name and location of hole, logging services performed, and the date and time of beginning and end of the log.

- 3.12 Logging run — A single data-collecting pass with a logging tool, as it moves up or down the borehole or a portion of the borehole. A given logging operation will generally consist of a main run and one or more repeat runs with each logging tool.
- 3.13 Logging tool — A sonde or device that is run in a borehole to make borehole logging measurements.
- 3.14 Logging tool stack — Two or more logging tools attached together and run as a single unit to save time and improve the depth correlation between logs.
- 3.15 Mudcake — A layer of mud that may be deposited on the borehole wall when the drilling fluid contains mud; when the liquid component of the mud invades the formation, the solid component may be left on the borehole wall.
- 3.16 Percussion gun — A device run on a wireline to obtain samples from a borehole wall. On a single run, multiple sample tubes or hollow shells are driven into the borehole wall at various depths by explosives and retrieved along with the samples.
- 3.17 Repeat run — A logging run, which may cover only a portion of the depth range of the main logging run, used to help judge data repeatability, as a check on instrument drift, and other data quality problems. The repeat run may be performed before or after the main run.
- 3.18 Site-Specific Health and Safety Plan (SSHASP)—A health and safety plan that is specific to a site or ER-related field activity that has been approved by an ER health and safety representative. This document contains information specific to the project including scope of work, relevant history, descriptions of hazards by activity associated with the project site(s), and techniques for exposure mitigation (e.g., personal protective equipment [PPE]) and hazard mitigation.
- 3.19 Verification — A test or tests, generally performed before and after logging in lieu of a calibration, to ascertain whether the logging system is operating properly. The verification differs from a calibration in that it does not provide updated system-calibration values.
- 3.20 Wireline — The logging cable used to support the logging tool and carry electrical power and signals between the tool and surface instrumentation.

## 4.0 BACKGROUND AND PRECAUTIONS

**Note:** This SOP is to be used in conjunction with an approved SSHASP. Also, consult the SSHASP for information on and use of all PPE.

### 4.1 Overview of Borehole Logging

#### 4.1.1 Introduction

In ER applications, borehole-logging techniques are used for the *in situ* determination of physical, chemical, geological, and hydrological parameters in boreholes. Borehole measurements can be used to help solve waste-cleanup problems as part of initial site characterization, during remediation, and for postremediation monitoring.

For accurate results to be achieved with a given logging system, it is essential that the system be calibrated against accepted standards and monitored for any malfunction or significant drift of the system calibration. In addition, the data must be corrected for nonstandard conditions (conditions other than those encountered in the calibration).

#### 4.1.2 Types of Logs

These logs are created in the field notebook and incorporated into the Column Lithography and Borehole Geophysical logs (refer to ER-SOP-3.02).

##### 4.1.2.1 Contaminant Mapping Logs

Contaminant Mapping Logs provide direct information on the presence of contaminants inside or outside the borehole. Borehole-logging devices exist that can estimate concentrations of certain contaminants. Even though Contaminant Mapping Logs are not Environmental Protection Agency-approved for quantitative analysis at the present time, they can, nonetheless, be used for screening and for supplying information on contamination between the locations of physical sample points along the borehole.

##### 4.1.2.2 Engineering Logs

This category includes all logs that are not used for contaminant mapping. Examples include caliper (borehole diameter), induction resistivity (formation electrical resistivity), and gamma-gamma density (formation bulk density).

#### 4.1.2.3 Borehole Samples

While not strictly logs, borehole samples can be obtained by some logging contractors. Typically, these take the form of borehole fluid samples, sidewall cores, or percussion-gun samples.

#### 4.1.3 Calibration

Accurate calibrations are necessary for the data to be used quantitatively; calibrations also play an important role in monitoring tool performance over time. The CSLPs must include a complete set of written calibration procedures for all logging equipment involved in quantitative measurements. The logging contractor is responsible for maintaining full and complete documentation for all calibrations of all tools and shall provide copies of these records to the FTL for transfer to the Records Processing Facility (see section 8.0).

### 4.2 Health and Safety Concerns

Potential hazards during a logging operation are associated with machinery, electrical devices, radioactive sources, weather, possible contact with contaminants, and other hazards. Some of these hazards are listed below; this is not a comprehensive list.

#### 4.2.1 The potential hazards of machinery operation can include

- winch problems such as drum brake failure, having the cable jump the flange, a loss of winch power, the cable becoming “birdcaged” or tangled, and having insufficient pulling power;
- rigging problems such as the cable jumping out of the sheave or the failure of the sheave wheel, tie downs, or supports; and
- logging-tool problems such as it becoming stuck in the borehole due to a hole collapse, the cable pulling out of the cable head at the tool, cable key-seated.

#### 4.2.2 Electrical devices can pose two types of hazards, either

- direct electrical hazards such as electrical shock and burns and electrical fires or
- indirect hazards such as the failure of the depth system or the failure of the weight system (tension).

#### 4.2.3 Radioactive sources include

- both high-intensity isotopic or chemical gamma-ray and neutron sources and also
- pulsed-neutron sources that may be accidentally actuated.

#### 4.2.4 Weather can also affect a logging operation.

- High winds increase machinery and electrical hazards.
- Rain increases electrical-shock hazard.
- Lightning is hazardous to both people and equipment.
- Exposure can impair logging equipment's efficiency and accuracy.

#### 4.2.5 Contamination

All material coming out of the borehole, including logging equipment, must be monitored for contamination, and the air near the top of the borehole must be monitored for volatile organic compounds. Site workers should be aware of logging operations at all times and read and understand both the ER Project Health and Safety Plan and the SSHASP for that work site.

#### 4.2.6 Other hazards include

- fuel fires;
- carbon monoxide fumes;
- problems on drilling rig that might affect the operation; and
- personnel problems such as inadequate training, carelessness, inattention, or impairment (due to medication, drugs, ailments, etc.).

## 5.0 EQUIPMENT

The list of equipment required for borehole logging varies with the contractor and the specific log(s) being run. Refer to the BLTSs and CSLPs for required equipment lists.

## 6.0 PROCEDURE

**Note:** Deviations from SOPs are made in accordance with QP-4.2.

**Note:** The logging equipment will be operated in accordance with applicable industry standards and regulatory requirements and this procedure.

### 6.1 Before Soliciting Bids on the Logging Contract

Before soliciting bids on the logging contract for an OU, detailed BLTSs must be prepared by the PI for borehole geophysics, in consultation with the FTL and OUPL. The success of the logging operation depends to a large degree on these specifications. The BLTSs must define the

- type of logging system,
- required logging parameters,
- precision,



- data accuracy and repeatability,
- depth accuracy,
- sample interval,
- calibration schedules and requirements, and
- data formats and media.

## 6.2 Before Letting the Logging Contract

Specific, detailed procedures depend on the logging system and the logging contractor being used. These CSLPs must be prepared and submitted by the prospective logging contractor for approval by the OUPL in consultation with the PI for borehole geophysics before the contract is finalized. The CSLPs should conform to the general procedures given in this SOP.

## 6.3 Preparing for the Logging Operation

### 6.3.1 The **FTL** will

- ensure that approval for property access has been obtained;
- review the site-specific SAP, the Drilling Package including the BLTSs, and the SSHASP for specific information on field activities;
- verify that the logging equipment meets the BLTSs; and
- verify that the CSLPs meet the specifications outlined in the BLTSs for each logging method to be applied.

### 6.3.2 The **FTL** will have the work site cleared of all brush and minor obstructions and have the location of utilities properly staked and identified.

### 6.3.3 The **FTL** will ensure that

- the specific logging equipment to be used has been shop calibrated within the required time period before the logging operation as specified in the BLTSs;
- all logging equipment has been shop calibrated after any repair or modification even if the equipment is not yet due for a routine shop calibration;
- all calibration(s) were within acceptable accuracy tolerances as defined in the BLTSs; and
- all logging equipment—including cable, cable head, and logging tool—has been decontaminated before use.

### 6.3.4 The **FTL** will prepare to monitor both the borehole air and the logging equipment as it emerges from the borehole for contamination. (Refer to the SOPs in Section 7.0, References, for guidance.)

## 6.4 The Logging Operation

- 6.4.1 The FTL will ensure that logging operations are carried out as specified in the CSLPs.
- 6.4.2 The FTL will ensure that each logging tool which is to be run is field calibrated or field verified as required in the BLTSs. A field calibration or verification is usually required both immediately before and immediately after a logging run or runs with a given logging tool. Ensure that this process is properly carried out according to the CSLPs and that the readings are within acceptable limits as defined in the BLTSs.
- 6.4.3 The FTL will ensure that the logging equipment is decontaminated between sampling events as specified in ER-SOP-1.08.
- 6.4.4 If borehole samples have been obtained by the logging contractor, such as water samples, sidewall cores, or percussion-gun samples, the FTL will ensure that borehole materials are field screened for hazardous and radioactive constituents.
- 6.4.5 If borehole materials prove hazardous, the FTL will take appropriate action for handling. Handle hazardous borehole materials according to procedures established in SOPs in the SOP Manual, Section 1.0.
- 6.4.6 The FTL will ensure that a Chain-of-Custody/Request for Analysis Form (Attachment C in ER-SOP-1.04) is completed for all analytical samples and accompanies the samples to the Sample Management Office.
- 6.4.7 The FTL will monitor the collection and containerizing of all waste materials and decontamination solutions for proper disposal, as described in ER-SOP-1.06.

## 6.5 After the Logging Operation

- 6.5.1 The FTL will ensure that log headers are correct and complete and meet the specifications given in the BLTSs. The FTL will then sign and date the form as a witness.
- 6.5.2 The FTL will obtain copies of field data in hard-copy form (bluelines) and digital form (magnetic tapes or other form), as specified in the BLTSs. These field copies are an important part of the data quality record even though reprocessed data may be submitted by the logging contractor at a later date.
- 6.5.3 The FTL will ensure that all borehole logging equipment is accounted for, decontaminated, and ready for transport.

- 6.5.4 The FTL will ensure that the site is restored to prelogging conditions or as specified in the SAP. The FTL will also ensure that the borehole is capped and/or marked as required.

## **7.0 REFERENCES**

The following documents have been cited within this procedure.

Borehole Logging Technical Specifications

Contractor-Specific Logging Procedures

QP-2.2, Personnel Orientation and Training

QP-4.2, Standard Operating Procedure Development

QP-4.3, Records Management

ER-SOP-1.04, Sample Control and Field Documentation

ER-SOP-1.06, Management of Environmental Restoration Project Wastes

ER-SOP-1.08, Field Decontamination of Drilling and Sampling Equipment

ER-SOPs in the SOP Manual, Section 1.0, General Instructions

ER-SOP-3.02, General Surface Geophysics

## **8.0 RECORDS**

The **FTL** is responsible for submitting the following records (processed in accordance with QP-4.3, Records Management) to the Records Processing Facility.

- 8.1 Hard copies of logging data ("bluelines") with completed headers, signed by logging-contractor representative and the FTL, or other approved witness, as specified in the BLTSS.
- 8.2 Digital data on magnetic tape or as otherwise specified in the BLTSS.
- 8.3 A Borehole Log Quality Report (BLQR) for each logging service run, as specified in the BLTSS. Completing the BLQR is the responsibility of the FTL.
- 8.4 Calibration records as specified in the BLTSS.
- 8.5 Completed Chain-of-Custody/Request for Analysis Form (Attachment C in ER-SOP-1.04) for borehole samples, if any.

## **9.0 ATTACHMENTS**

None